BTEC Assignment Brief

Qualification	Pearson BTEC International Level 3 Subsidiary Diploma in Applied Science Pearson BTEC International Level 3 Foundation Diploma in Applied Science Pearson BTEC International Level 3 Diploma in Applied Science Pearson BTEC International Level 3 Extended Diploma in Applied Science Pearson BTEC International Level 3 Extended Diploma in Biomedical Science Pearson BTEC International Level 3 Extended Diploma in Environmental Science
Unit number and title	**Unit 16: Applications of Inorganic Chemistry**
Learning aim(s)	**C:** Investigate acid-base equilibria in order to understand acid-base titration procedures and applications of buffer solutions
Assignment title	**Acid-base equilibria**
Assessor	
Issue date	
Hand in deadline	

Vocational Scenario or Context	You are a laboratory technician working for a chemical company that specializes in making inorganic compounds. In your role you need knowledge of how acids, bases, pH and buffers solutions are important in many different industrial sectors/services for example in hospitals, forensic science, medicine, environmental science, horticulture, construction, medicine and engineering. Practical experience and an understanding of acid-base equilibria, acid-base titrations, pH and buffers are essential for scientists and technicians working in analytical laboratories. In terms of health and safety, it is of particular importance that the general public has a knowledge of acids, bases and pH when dealing with products for example used in cooking, cleaning, gardening, washing and DIY. Your supervisor has set up some Continuing Professional Development (CPD) for you to ensure that your knowledge and skills remain up to date.

Task	As part of your annual CPD in your role of laboratory technician you are required to **investigate** the action of a buffer solution**, plot** pH curves and determine K_a values and **compare** pH values from experiments and calculated values. Your supervisor has also asked you to prepare a report that **evaluates** acid-base titration techniques and buffer solutions and **explains** the shape of pH curves and use of indicators**.** You will also be asked to **perform** complex calculations involving pH and K_a. Your final portfolio must contain the following five sections: Section 1- 'pH and Acid Dissociation Constants Calculations Test' • Your Supervisor will provide you with the 'pH and Acid Dissociation Constants Calculations Test 'to enable you to **perform** a series of complex calculations involving pH and acid dissociation constants.

Section 2 - Action of a buffer solution

- **Investigate** the action of a buffer solution by making an acidic buffer solution. Calculate its pH and compare this to a measured pH. Specify the sizes of the pH changes observed and the quantities of acid and alkali added.
    - You will make a buffer solution using ethanoic acid as the weak acid and sodium ethanoate as its conjugate base / salt. Using an accurately calibrated pH meter, measure the pH of your solution. Use the Henderson-Hasselbach equation to calculate the theoretical pH of your solution and compare it with the actual pH measured.
    - Having made your buffer solution, **investigate** buffer action further by adding small amounts of a strong acid and of a strong alkali to separate samples of the solution (e.g. a few drops followed by 1 cm^3 and finally a larger quantity of 0.1 mol dm^{-3} solution). Measure the quantities of acid or alkali added during your experiment and the pH reading. Record your results in a logical table and draw clear conclusions from your results that explains the buffer action of your solution and the limits of this action.
- Choose ONE of the following applications of buffer action:
    - acidity regulators in food
    - citric acid-citrate in shampoo
    - carbonic acid-hydrogencarbonate
    - buffers in controlling blood pH

  For your chose application explain the buffer action and **evaluate** its efficiency in terms of the Henderson-Hasselbalch equation

Section 3 – pH Titrations

- Carry out pH titrations of the following solutions (use 0.1 mol dm^{-3} concentrations), adding 0.5 cm^3 of titrant at a time (reduce this to 0.1 cm^3 when close to the end point) and noting the pH (measured using an accurately calibrated pH meter):
    - 25 cm^3 of hydrochloric acid titrated with sodium hydroxide
    - 25 cm^3 of hydrochloric acid titrated with ammonia solution
    - 25 cm^3 of ethanoic acid titrated with sodium hydroxide
    - 25 cm^3 of ethanoic acid titrated with ammonia solution.

  Present your readings of volume of alkali and pH in a logical results table. Ask your assessor to complete a witness statement or observation record that witnesses your accurate use of a pH meter to gather data. Alternatively, you could video record your use of the pH meter and submit this as evidence.
- Using Excel® (or other suitable computer software), plot scatter graphs of pH against volume and ΔpH/Δvolume against volume to determine the end point for each of the titrations.
- For the pH curve of ethanoic acid titrated with sodium hydroxide determine the acid dissociation constant K_a for the ethanoic acid, using the measured pH of the half neutralized solution and the relationships $pH = pK_a$ and $K_a = 10^{-pKa}$
- **Explain** the shape of your pH curves for your four titrations. Use acid-base equations, calculations involving $[H^+] = 10^{-pH}$ and buffer action theory to support your explanations of your pH observations. State which indictors you used in each case and **explain** why these indicators were the most suitable for each different titration.

	Section 4 – **Comparison** of pH measurements with calculated pH values • **Compare** pH measurements with calculated pH values for concentrations of supplied solutions using pH = -log [H^+]. Use a calibrated pH meter to measure pH values for the selection of solutions that includes strong acids, strong alkalis and weak acids at different concentrations. Use suitable acid or base dissociation equations to explain your results and calculate the concentration of H^+ ions from the measured pH using the equation [H^+] = 10^{-pH}. Section 5 Evaluation of different acid-base titration techniques? • **Evaluate** the good and bad points of acid-base titrations as an analytical technique. This should cover three different titration techniques: titration using a pH meter, titration using an indicator and titration by autotitrater. This should be based upon a variety of sources of information, examine strengths and weaknesses of each, and allow you to draw a conclusion on the best use of each. Your evaluation of each technique should include consideration of: o accuracy of results o cost of equipmet o maintenance and calibration o amounts of titrant used You should not assume that the more automated a process, the more accurate it will be.
Checklist of evidence required	A report that includes: • A comparison of experimentally determined and calculated pH values • Plots of pH curves for acid-base titrations and determination the acid dissociation constant for a weak acid • An explanation of pH curves and the use of appropriate indicators • An investigation of the action of a buffer solution • The ‘pH and Acid Dissociation Constants Calculations Test’ • An evaluation of the use of acid-base titrations and efficiency of buffer solutions.

Criteria covered by this task:	
Unit/Criteria reference	To achieve the criteria, you must show that you are able to:
C.D3	Evaluate the use of different acid-base titration techniques and the efficiency

	of buffer solutions
C.M6	Explain the shape of pH curves and the use of appropriate indicators
C.M5	Perform complex calculations involving pH and K_a, including rearrangement of equations
C.P7	Investigate the action of a buffer solution
C.P6	Plot pH curves for a range of acid-base titrations and determine the acid dissociation constant K_a, for a weak acid
C.P5	Compare experimentally determined pH values against calculated values
Sources of information to support you with this Assignment	All sources of information suggested are UK based. Centres are free to amend these sources to those available in the Country of delivery where more appropriate. www.STEM.org.uk – Chemistry – pH, Equilibrium II – Acids-Bases www.edu.rsc.org - The pH scale, Acids and Bases starters (16-18) Within the copyright laws learners could search YouTube for – What is pH, How to calculate pH, Acids bases and pH, pK_a, K_a and acid strength, pH curves and pH indicators, Introduction to buffer solutions
Other assessment materials attached to this Assignment Brief	A data sheet with appropriate equations is included with this assignment brief. The Centre will be required to provide learners with an additional document that the Centre will design. This document should be internally verified as part of this assignment brief. The details are as follows: • The 'pH and Acid Dissociation Constants Calculations Test' which, should allow learners to perform a series of complex calculations involving pH and acid dissociation constants. For example, learners could be given the pH and the concentration of a weak acid and asked to calculate the acid dissociation constant for a weak acid or calculate the pH of a buffer solution from the acid dissociation constant for a weak acid and concentrations of weak acid and salt.
Notes to the Assessor and technician	The practical activities suggested for this assignment are required to be safety checked by the Centre before use. Pearson Education can take no responsibility for the safety of any practical activities. Before doing any practical activity, you should always carry out your own risk assessment and refer to the necessary regulations. In particular, any local rules issued by your employer must be obeyed, regardless of what is suggested here. Centre should use Health and Safety information provided by a reputable source. In the UK such an example organization is CLEAPSS http://science.cleapss.org.uk/

DATA SHEET

Table of dissociation constant data

Weak acid	***K_a / mol dm^{-3} at 25^{oC}***
Ethanoic acid	*1.7 x 10^{-5}*
Methanoic acid	*1.8 x 10^{-4}*
Phosphoric acid	*7.1 x 10^{-3}*
Tartaric Acid	*9.2 x 10^{-4}*

Formulae for questions:

To calculate pH from concentration of hydrogen ions, [H^+], and vice-versa

$$\mathbf{pH = -\log [H^+]} \quad \textit{and} \quad \mathbf{[H^+] = 10^{-pH}}$$

For strong monoprotic acids of formula HA, assume that dissociation into ions is complete, so

$$\mathbf{[H^+] = [HA]}$$

For strong diprotic acids of formula [H_2A],

$$\mathbf{[H^+] = 2 \times [H_2A]}$$

For weak acids of formula HA,

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For alkalis, concentration of H^+ ions is

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where the ionic dissociation constant of water, ***K_w = 1 x 10^{-14} mol^2 dm^{-6}*** *at 25°C*

For strong alkalis of formula MOH, assume that dissociation into ions is complete, so

$[OH^-] = [MOH]$

For strong alkalis of formula $M(OH)_2$,

$[OH^-] = 2 \times [M(OH)_2]$

For buffer solutions, where [HA] = concentration of weak and $[A^-]$ = concentration of conjugate base,

$$pH = -\log K_a + \log ¿¿$$

(This is the Henderson-Hasselbach equation)